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Description

METAL SHEET DRILLING DISK ROLL, METAL SHEET DRILLING
DEVICE AND METAL SHEET DRILLING METHOD WHICH USE THE DISK ROLL,
AND DRILLED METAL SHEET PRODUCED BY USING THE DISK ROLL

Technical Field

This invention relates to a metal sheet drilling disk roll for making holes successively in a long belt-like metal sheet or metal foil, a metal sheet drilling device and a metal sheet drilling method which use the same roll, and a drilled metal sheet produced by using these metal sheet drilling device and metal sheet drilling method.

Background Art

In recent years, a demand for a drilled metal sheet in which a multiplicity of holes are made so that the drilled metal sheet is used as a base for a secondary battery electrode has increased. The drilled metal sheet for a secondary battery electrode base is wound with an active material deposited on a surface thereof, and loaded into a battery case. The holes are made in the metal sheet for the purpose of giving an anchoring effect to the active material to promote the adhesion thereof to the metal sheet, and also filling the holes with the active material. In order to increase the capacity of a

battery, it is necessary to load the largest possible quantity of active material into the battery case, so that the thinnest possible metal sheet is demanded as a metal sheet to be drilled and used for an electrode base.

A method of drilling a metal sheet by using a dieing out press has heretofore been generally used as a drilled metal sheet manufacturing method. However, in a drilling method using a press, a metal sheet to be drilled is necessarily fed intermittently, and necessarily stopped when the metal sheet is pressed. Moreover, it was very difficult to improve the productivity of drilled metal sheets by increasing a drilling speed while exerting a great force on the press.

Japanese Patent Laid-Open No. 133936/1985 discloses a method of continuously manufacturing drilled metal sheets by rotating a drilling roller having a multiplicity of projections as a method of improving the productivity of drilled metal sheets by increasing a drilling speed. The manufacturing of this metal sheet is done in the following manner. Namely, first, a metal sheet is passed continuously between a roller provided with a multiplicity of saw-tooth-like projections on an outer circumferential surface thereof and a receiving roller, and holes are thereby drilled by the projections with burrs raised at the same time. The drilled metal sheet advances continuously, and the burrs impinge upon an end of a scratch jig provided ahead of the drilled metal sheet, the burrs being

thereby folded back. The metal sheet further advances continuously, and is fed to a rolling roller provided ahead thereof. The metal sheet is then rolled, and the folded-back portions thereof eat into the metal sheet, so that a burr-less drilled metal sheet is formed. When this drilled metal sheet manufacturing method is used, carrying out a continuous drilling operation becomes possible, and a drilling speed increases to enable the improvement of the productivity of drilled metal sheets to be attained.

However, this method of continuously manufacturing a drilled metal sheet by rotating the above-mentioned projection-carrying drilling roller still had problems to be solved.

Namely, the thickness of the burr-folded-back portions becomes nearly two times that of the original metal sheet. When this metal sheet is used as a drilled metal sheet for a secondary battery electrode base, the volume of the metal sheet itself increases when the metal sheet with an active material deposited on a surface thereof and wound is loaded into a battery case, and the quantity of the active material loaded into the battery jar therefore decreases correspondingly, so that this method is not preferable to increase the capacity of the battery.

When the thickness of the folded-back portions is set equal to that of the other portion of the metal sheet by

increasing a rolling force, the folded-back portions only are rolled extremely and elongated since the thickness of these portions is nearly two times as large as that of the other portion of the metal sheet. Therefore, the distance between the holes made by a drilling operation increases to cause the density of the holes to decrease. When a metal sheet having such holes is used as a drilled metal sheet for a secondary battery base, the anchoring effect becomes insufficient, and the quantity of the active material packed in the holes decreases, so that such a drilled metal sheet is not preferable.

The present invention has been made in view of the above-mentioned circumstances, and provides a metal sheet drilling disk roll capable of drilling a multiplicity of uniform holes successively in a long belt-like metal sheet, especially, very thin metal foil used as a secondary battery electrode base while keeping the thickness of the metal sheet uniform; a metal sheet drilling device and a metal sheet drilling method which use the disk roll; and a drilled metal sheet produced by using the metal sheet drilling device and metal sheet drilling method.

Disclosure of the Invention

(1) The metal sheet drilling disk roll having on an outer circumferential surface of a disk roll body of a predetermined thickness a plurality of drilling blades formed in a

circumferentially spaced manner in a radially outwardly projecting state, wherein the shape in plan of an outer circumferential surface of each of the drilling blade is set to a geometric shape surrounded by one closed line, the shape in side elevation of the drilling blade being set concave so that the height of both of circumferential end portions of the drilling blade is larger than that of the other portion thereof with the height of the blade decreasing gradually from both of the circumferential end portions thereof toward a central portion thereof.

(2) A metal sheet drilling disk roll, wherein the disk roll is formed so that the height in side elevation of a preceding circumferential end portion of the drilling blade with respect to the rotational direction of the disk roll is smaller than that of a posterior circumferential end portion thereof with respect to the same direction.

(3) A metal sheet drilling disk roll, wherein the shape in plan of the drilling blade is set to a rectangular shape or a substantially rectangular shape with its four corner sections rounded.

(4) A metal sheet drilling disk roll, wherein the shape in plan of the disk roll is set to one of an elongated circular shape, an elliptic shape, a right circular shape, a rhomboidal shape, or a substantially rhomboidal shape with its four corner sections rounded.

(5) A metal sheet drilling device for making a plurality of holes in a metal sheet or metal foil, wherein the metal sheet drilling disk roll mentioned in one of the claim 1 to 3 is used as an upper roll, a pair of upper side guide rolls, the radius of each of which is reduced as compared with a distance between the center of the driving disk roll and the lowest portion of the drilling blade by at least not less than a length corresponding to the thickness of the metal sheet or metal foil, being connected to both sides of the upper roll coaxially to form an upper roll unit, a disk roll the diameter of which is slightly larger than that of the metal sheet drilling disk roll being provided as a guide roll, a pair of lower side guide rolls, the radius of each of which is increased as compared with that of the disk roll by at least a length corresponding to the sum of the thickness of the metal sheet or metal foil and a difference between an amount of projection of the highest portion of the drilling blade and that of projection of the lowest portion thereof, being connected to both sides of the guide roll coaxially to form a lower roll unit, the upper roll unit and lower roll unit being engaged with each other to form a drilling unit capable of drilling the metal sheet or metal foil with the drilling unit passed therethrough, tensile force application units formed of tensile force application means for applying a tensile force to the metal sheet or metal foil being provided on the front and rear sides of the drilling unit.

(6) A metal sheet drilling device, wherein a plurality of sets of each of upper roll units and lower roll units which constitute the drilling unit mentioned in the claim 5 above are connected together coaxially as will be mentioned in the claim 7, the metal sheets or metal foil being thereby made possible to be drilled in a plurality of rows.

(7) A metal sheet drilling device, wherein the upper roll units, lower roll units and tensile force application means being provided in positional relation in which the metal sheet or metal foil advances along a part of an outer circumference of the guide roll so that the metal sheet or metal foil is drilled as the metal sheet is wound round the guide roll.

(8) A metal sheet drilling device, wherein each of the tensile force application means mentioned in the claim 5 and claim 7 is formed of upper and lower pinch rolls adapted to hold the metal sheet or metal foil therebetween, or upper and lower bridle rolls.

(9) A metal sheet drilling method for drilling a metal sheet or metal foil by using the metal sheet drilling device mentioned in one of the claims 5 to 9, wherein the metal sheet or metal foil is passed through a pair of tensile force application units provided on the front and rear sides of the drilling unit, the metal sheet or metal foil being drilled successively by rotating the upper and lower rolls, which constitute the drilling unit, while applying tensile force to

the metal sheet or metal foil by tensile force application means constituting the tensile force application units.

(10) A drilled metal sheet manufactured by using the metal sheet drilling device mentioned in the claims 5 to 9, and the metal sheet drilling method mentioned in the claim 10 above.

Brief Description of the Drawings

Fig. 1 is a schematic diagram showing an example of the condition of a metal sheet being drilled by using a metal sheet driving disk roll according to the present invention;

Fig. 2 is a perspective view showing an example of the shape of drilling blades provided in a projecting state on an outer circumferential surface of the metal sheet driving disk roll according to the present invention;

Fig. 3 is a schematic diagram showing another example of the condition of a metal sheet being drilled by using the metal sheet drilling disk roll according to the present invention;

Fig. 4 is a schematic diagram showing a mode of drilling a metal sheet in a metal sheet drilling operation using the metal sheet drilling disk roll according to the present invention;

Fig. 5 is a schematic diagram showing an example of a drilling unit of the metal sheet drilling device according to

the present invention;

Fig. 6 is a schematic diagram showing an example of the metal sheet drilling device according to the present invention;

Fig. 7 is a schematic diagram showing another example of the drilling unit of the metal drilling device according to the present invention;

Fig. 8 is a schematic diagram showing another example of the metal sheet drilling device according to the present invention; and

Fig. 9 is a schematic diagram showing still another example of the metal sheet drilling device according to the present invention.

Best Mode for Carrying Out the Invention

The present invention will now be described in detail with reference to the drawings.

A metal sheet drilling disk roll according to the present invention is provided so as to make a multiplicity of holes in a metal sheet or metal foil of around 0.02 to 0.2 mm in thickness.

As shown in Fig. 1, the disk roll 1 is provided on an outer circumferential surface thereof with a plurality of drilling blades 2 in a circumferentially spaced manner and in a radially outwardly projecting state.

The shape in plan of each drilling blade on the outer

circumferential surface of the disk roll, i.e. a cross-sectional shape of a drilled hole is set to a geometrical shape surrounded by one closed line. In this embodiment, this shape is set rectangular.

As shown in Figs. 1 and 2, the shape in side elevation of each drilling blade 2 is set concave so that the height of front and rear edges 21, 22 thereof constituting both circumferential end portions of the drilling blade becomes larger than that of the other portions thereof with the height of the drilling blade becoming gradually smaller from the front and rear edges 21, 22 toward a central portion thereof.

As shown in Fig. 2, the drilling blade 2 is formed so that both side edges 23 thereof, which correspond to the portions of both-side closed lines opposed to each other in the circumferential direction of the disk roll 1, project lower than an imaginary straight line 24 connecting together the front and rear edges 21, 22 which correspond to the portions of both-side closed lines which are opposed to each other in the direction of the thickness of the disk roll 1.

The shape in plan of the drilling blade 2, i.e. the cross-sectional shape of the drilled hole can also be set to a substantially rectangular shape with its four corner portions rounded besides an accurate rectangular shape having the front edge 21, rear edge 22 and side edge 23 as shown in Fig. 2.

The front and rear edges 21 and 22 constituting the two

circumferential end portions on the outer circumferential surface of the disk roll 1 of the drilling blade 2 can be formed so that the height of the front edge 21 thereof, a circumferentially preceding end portion which eats into the metal sheet or metal foil (which will hereinafter be referred to generically as a metal sheet) 10 first in accordance with the rotation of the disk roll 1 as shown in Fig. 3 is smaller than that of the rear edge 22 thereof, a circumferentially posterior end portion which is thereafter eats into the metal sheet 10. Since the shape in side elevation of the driving blade 2 is set in this manner, the front edge 21 and rear edge 22 can be made so that these edges eat into the metal sheet 10 at once as shown in Fig. 3.

The shape in plan of the drilling blade 2 can also be formed to other shapes, for example, desired geometric shapes, such as an elongated circular shape, an elliptic shape, a right circular shape, a rhomboidal shape, or a substantially rhomboidal shape with its four corner portions rounded, etc. in accordance with the property of the metal sheet instead of setting the shape to the above-mentioned rectangular shape and a substantially rectangular shape.

The construction of the metal sheet drilling device according to the present invention will now be described with reference to Fig. 6.

As shown in the drawing, the metal sheet drilling device

includes a drilling unit 20, upper and lower pinch rolls 6a, 6b provided on the front side and rear side of the drilling unit 20 as tensile force application means, and tensile force application units 30 having 17a, 17b. On the other hand, the drilling unit 20 is formed by providing on the outer circumferential surfaces of the upper and lower rolls 11, 12 with drilling blades 2 in a circumferentially spaced manner.

As shown in Fig. 9, upper and lower bridle rolls 16a, 16b and 17a, 17b may also be used as the tensile force application means.

In the metal sheet drilling device having the above-described construction, the drilling portion 2 can have the construction shown, for example, in Fig. 5.

Namely, as shown in Fig. 5, a pair of disk rolls 3 the radius of each of which is set shorter than a distance between the center of the metal sheet drilling disk roll 1 and the lowest portion (lowest portion of the side edge 23) of the edge of the drilling blade 2 by at least a length corresponding to the thickness of the metal sheet 10 are connected coaxially as upper side guide rolls to both sides of the metal sheet driving disk roll 1 to form an upper roll unit 11.

A disk roll the thickness of which is slightly larger than that of a disk of the metal sheet drilling disk roll 1 is provided as a guide roll 4, and a pair of disc rolls 5 the radius of each of which is set larger than that of the guide

roll 4 by at least a length corresponding to the sum of the thickness of the metal sheet 10 and a difference between an amount of projection of the highest portion (front edge 21 or rear edge 22) of the drilling blade 2 and that of projection of the lowest portion (side edge 23) thereof being connected to both sides of the guide roll coaxially to form a lower roll unit 12.

The above-mentioned upper roll unit 11 and lower roll unit 12 are engaged with each other, the drilling unit 20 being thereby formed.

Another example of the drilling unit 20 of the metal sheet drilling device according to the present invention will be shown in Fig. 7. As shown in the drawing, the drilling unit 20 is formed by the metal sheet drilling disk roll 1 and guide roll 4 arranged in a vertically symmetric manner with respect to the center of the metal sheet 10. The guide roll 4 having a thickness slightly larger than that of the disk of the metal sheet drilling disk roll 1 is provided on the portions of the outer circumferential surface thereof which are opposed to the plural drilling blades 2 formed so as to project in the radially outward direction with a plurality of recesses 42 each of which has a cross-sectional shape identical with the shape in plan (i.e. the shape of a cross section of a drilled hole) of the drilling blade 2.

The guide roll 4 of an elastic material, such as rubber

can also be formed of a disk having a flat outer circumferential surface without forming a recessed portion 42 having a cross section identical with that of the drilled hole as mentioned above. In this case, the drilling blade 2 provided on the metal sheet drilling disk roll 1 eats into the outer circumferential portion of the upper roll unit 12 during a drilling operation, and the outer circumferential portion of the guide roll 4 is elastically deformed in accordance with the shape of the drilling blade 2. However, when the hole drilling operation finishes to cause the drilling blade 2 to be disengaged from the guide roll 4, the shape of the drilling blade 2 is restored to that of a disk having the original flat outer circumferential surface.

In order to make a plurality of rows of holes in the metal sheet 10 so that the holes are parallel spaced in the widthwise direction, a metal sheet drilling device can also be formed by connecting a plurality of sets of upper rolls 11 and lower rolls 12, which constitute the above-mentioned drilling unit 20, to each other coaxially in the axial direction of each roll shaft as shown in Fig. 8.

The drilling blade 2 in the present invention is formed on the outer circumferential surface of the disk roll 1 in a radially outwardly projecting state so as to be spaced at regular intervals in the circumferential direction as shown in Fig. 1. When the disk roll 1 is rotated, the metal sheet

10 provided with undrilled hole portions at regular intervals is subjected to drilling. It is also possible to provide some of adjacent drilling blades 2 at intervals larger than those of the other thereof instead of providing the drilling blades on the outer circumferential surface of the metal sheet at regular intervals in the circumferential direction thereof. Namely, it is possible to form a disk roll 1 having no drilling blades 2 on a part of the outer circumferential surface thereof, and drill the metal sheet 10 by rotating the resultant disk roll so that the metal sheet has in the lengthwise direction thereof undrilled hole portions spaced at predetermined intervals larger than those of the other drilled portions. Thus, it becomes possible to provide undrilled portions at regular intervals larger than those of the other undrilled portions, and cut the metal sheet 10 at the greatly spaced undrilled portion thereof. Especially, when the sheet drilling device formed as mentioned above, by connecting a plurality of sets of the upper roll 11 and lower roll 12, which constitute the drilling unit 20, to each other coaxially in the axial direction of each roll, is used to drill holes in the metal sheet 10 in a staggered manner in the widthwise direction thereof, an object portion of the metal sheet 10 can be cut irrespective of the presence of the staggeringly arranged drilled portions on the metal sheet. When the metal sheet 10 is used as a core of a battery, it is possible to provide

undrilled portions, the intervals of which are larger than those of other portions, at predetermined intervals so that the distance between drilled portions agrees with the length of the core needed for one battery. This enables the metal sheet 10 to be cut without causing both of lengthwise end portions thereof to fall on drilled portions. Such intervals of the undrilled portions that are larger than those of the other undrilled portions can be changed arbitrarily by selecting the diameter of the disk roll.

A method of making a multiplicity of holes successively in a metal sheet 10 by using the metal sheet drilling disk roll 1 according to the present invention and the metal sheet drilling device according to the present invention will now be described with a case where the shape in plan (cross-sectional shape of a drilled hole) of a drilling blade 2 of the metal sheet drilling disk roll 1 is rectangular taken as an example will now be described with reference to Fig. 4.

According to the present invention, a metal sheet of around 0.02 to 0.2 mm in thickness, and, especially, extremely thin metal foil of not larger than 0.1 mm in thickness is drilled.

As described above, the metal sheet drilling device according to the present invention includes as shown in Fig. 6 a drilling unit 20, a pair of pinch rolls 6a and 6b provided ahead of the drilling unit 20, and a tensile force application

units 30 formed of a pair of pinch rolls 7a and 7b provided at the back of the drilling unit 20. As mentioned above, the pinch rolls may be replaced with upper and lower bridle rolls as shown in Fig. 9.

In order to drill the metal sheet 10, first, a tensile force is applied to the portion of the metal sheet 10 which is between the pinch rolls 6a and 6b and 7a and 7b which constitute tensile force application means. The metal sheet 10 is passed continuously between the upper and lower rolls 6a, 6b and upper and lower rolls 7a, 7b which constitute the drilling unit 20 and tensile force application unit 30 with the tensile force applied condition maintained.

When the metal sheet 10 with a tensile force applied thereto is brought into contact with the metal sheet drilling disk roll 1, the upper roll 11 of the drilling unit, first, a front edge 21 of a drilling blade 2 and a part of a side edge 23 extending from the front edge 21 eat into the metal sheet 10 as shown in Fig. 4 i) to cause a break to occur.

When the metal sheet drilling disk roll 1 is further rotated, the mentioned part of the side edge 23 extending from the front edge 21 of the drilling blade 2 further eats into the metal sheet as shown in Fig. 4 ii), and the break stretches with the rear edge 22 of the drilling blade 2 and the part of the side edge 23 which extends from the rear edge 22 eating into the metal sheet 10 to cause a break to occur.

When the metal sheet drilling disk roll 1 is further rotated, the mentioned part of the side edge 23 extending from the front edge 21 of the drilling blade 2 further eats into the metal sheet as shown in Fig. 4 iii), and the break stretches with the mentioned part of the side edge 23 which extends from the rear edge 22 of the drilling blade 2 further eating into the metal sheet to cause the break to stretch. The break in the side edge 23 thus comes to stretch from both sides, i.e., from the front edge 21 and rear edge 22.

When the metal sheet disk roll 1 is further rotated, the break in the side edge 23 extending from both the front edge 21 and rear edge 22 are joined together as shown in Fig. 4 iv), and a hole of a rectangular shape is formed in the metal sheet 10.

When the metal sheet disk roll 1 is further rotated, a subsequent drilling blade 2 eats into the metal sheet 10, and a rectangular hole is formed in the same manner as mentioned above.

When the metal sheet drilling disk roll 1 is thus rotated, rectangular holes can be formed successively in the metal sheet 10 in a spaced manner.

When in this case the height of the front edge 21 forming a preceding circumferential end portion which eats into the metal sheet 10 first in accordance with the rotation of the disk roll 1 is set lower than that of the rear edge 22 forming

a posterior circumferential end portion which thereafter eats into the metal sheet 10 as shown in Fig. 3, it becomes possible to have the front edge 21 and rear edge 22 eaten into the metal sheet 10 at once, and make rectangular holes in the metal sheet 10 more accurately and reliably.

In the case where a metal sheet drilling operation is carried out in practice with a tensile force not applied to the metal sheet 10, which is made of, especially, metal foil of an extremely small thickness of not larger than 0.1 mm, the rigidity of the metal sheet lowers even when the height of the portions constituting intermediate portions between the front edge 21 and rear edge 22 is set lower than those of the front and rear edges 21, 22 as shown in Fig. 2, i.e., even when a metal sheet drilling disk roll 1 in which the portion of the blade corresponding to the side edge 23 projects lower than an imaginary straight line connecting together the apexes of the portions of the blade which correspond to the front edge 21 and rear edge 22 is used. As a result, it becomes difficult to have the portions of the blade which correspond to the front edge 21 and rear edge 22 eat into the metal sheet, and make accurately shaped holes successively. Therefore, it is preferable to give a tensile force to the metal sheet 10 when metal foil of extremely small thickness of not larger than 0.1 mm is drilled.

When a method of moving the metal sheet 10 so that the

metal sheet winds round a part of the outer circumference of the guide roll 2 (lower roll 12) as shown in Fig. 9, and drilling the metal sheet with the metal sheet 10 brought into close contact with the lower roll 12 is used, metal foil of an extremely small thickness of not larger than 0.1 mm can be drilled more reliably. In this case, the upper and lower bridle rolls 16a and 16b and 17a and 17b, which serve as tensile force application means, and upper roll 11 and lower roll 12 are provided in the positional relation which permits the metal sheet to advance along a part of the outer circumference of the guide roll 2 (lower roll 12), and not in the positional relation shown in Fig. 9, i.e., not in the positional relation in which the metal sheet 10 is moved linearly between the drilling unit 20 and tensile force application units 30 as shown in Fig. 6.

Fig. 5 and Fig. 7 show a case where holes are formed in one row in a metal sheet 10. As shown in Fig. 8, it is possible to form a metal sheet drilling device by arranging a plurality of sets of lower rolls 12 and upper rolls 11, which constitute a metal sheet drilling unit, coaxially in the axial direction of the rolls, and make in a metal sheet 10 a plurality of widthwise arranged rows of substantially rectangular holes successively in a lengthwise spaced manner. When in this case the intervals of drilling blades 2 of adjacent metal sheet drilling disk rolls 1 are mutually regulated, making holes in

an arbitrary arrangement, such as a staggered arrangement and a latticed arrangement and the like can be done.

The drilled metal sheet having a multiplicity of holes according to the present invention can be made by using the above-mentioned metal sheet drilling device having a metal sheet drilling disk roll 1, and the above-mentioned metal sheet drilling method. The drilled metal sheet having a multiplicity of holes according to the present invention can be formed by making uniform holes successively and accurately in, especially, metal foil of an extremely small thickness of not larger than 0.1 mm. Since such a drilled metal sheet does not have projecting portions, such as folded-back portions and the like, the metal sheet is suitable for a base for a secondary battery electrode.

(Embodiment)

30 sets of metal sheet drilling disk rolls (upper rolls) were prepared each of which was formed of a disk of alloy tool steel (SKS1) of 1 mm in thickness and 80 mm in diameter and provided on its outer circumferential surface with 60 drilling blades so that the blades were spaced at 1.59 mm intervals and projected in the radially outward direction, each of which blades had a rectangular drilling section of 2.6 mm in circumferential length and 1 mm in width.

Each of the drilling blades was formed in a projecting manner so that the height (maximum height) of rectangular front

edge and rear edge projecting at front and rear portions of the blade with respect to the direction of the thickness of the disk roll became 1 mm with the height (minimum height) of the centers of side edges projecting at left and right portions of the blade with respect to the circumferential direction 0.5 mm so as to vary the height of the front edge ~ the centers of the side edges ~ the rear edge continuously and arcuately.

31 sets of disk rolls (upper side guide rolls) of 80 mm in diameter formed of alloy tool steel (SKS1) of 1 mm in thickness were prepared. The metal sheet drilling disk rolls and side guide rolls were arranged alternately and coaxially so that the rolls at both ends became side guide rolls with the distance between each side guide roll and each metal sheet drilling disk roll becoming 0.05 mm, by inserting spaces therebetween and thereby regulating the distance, to form upper rolls.

On the other hand, 30 sets of disk rolls (guide rolls) of 80 mm in diameter were prepared from alloy tool steel (SKS1) of 1.1 mm in thickness. Also, 31 sets of disk rolls (lower side guide rolls) of 81 mm in diameter were prepared from alloy tool steel (SKS1) of 1 mm in thickness. The guide rolls and side guide rolls were arranged alternately and coaxially so that the rolls at both ends became side guide rolls, to form lower rolls.

The upper rolls and lower rolls thus prepared were

engaged with each other to form a drilling unit. The drilling blades of adjacent upper rolls were lined so as to stagger the blades thereof by a half pitch in the circumferential direction so that the holes formed after a drilling operation were arranged in a staggered manner.

Moreover, a pair of bridle rolls were provided at each of the front and rear sides of this drilling unit in such positional relation that permitted a metal sheet to advance so as to wind round a part of the outer circumference of the lower roll of the drilling unit as shown in Fig. 9, to form tensile force application units. The rotational speed of the front bridle roll was set slightly higher than that of the rear bridle roll so that a tensile force be applied at all times to the portion of the metal sheet which is between the two bridle rolls. Thus, the metal sheet drilling device was formed.

A long belt-like nickel plated steel foil of 0.035 mm in thickness and 65 mm in width was then drilled by using the above-mentioned metal sheet drilling device. The rotational speeds of the bridle roll in front of the tensile force application unit, bridle roll at the back thereof and upper and lower rolls of the drilling unit were set respectively so that the steel foil advances at a speed of 1 m/sec. The rotational speeds of the bridle rollers were set so that 2 kgf tensile force was exerted on the portion of the metal sheet which was between the front bridle roll and rear bridle roll.

Thus, rectangular holes of 2.6 mm in length and 1 mm in width were made successively at 1.59 mm intervals in the lengthwise direction, and nickel plated steel foil having 30 rows of holes made in a staggered manner at 1.1 mm intervals in the widthwise direction thereof was obtained.

Industrial Applicability

The present invention relates to a metal sheet drilling device and a metal sheet drilling method which use a metal sheet driving disc roll provided on an outer circumferential surface thereof with a plurality of drilling blades arranged in a circumferentially spaced manner and in a radially projecting state. Using the metal sheet drilling device and metal sheet drilling method according to the present invention has enabled a multiplicity of uniform holes of a constant depth to be made successively in a long belt-like metal sheet, especially, long belt-like metal foil used for a base for a secondary battery electrode.